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Rural electrification in China: A policy and institutional analysis

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ABSTRACT

The low level electrification in rural China could be ascribed to lack of supporting policies, weak institutional frameworks and limited financing channels. Over the past three decades, Chinese government has been making various efforts in both policies and financing to improve rural electrification. Thus, remarkable achievements have been made in this field. The rural electrification rate has exceeded 99 percent and the electricity demand of production and living has been basically met. The rural economy and society, infrastructures and eco-environment have been significantly improved thanks to the electrification development. Also, the gap of electrical facilities between the urban and the rural has been narrowed. However, there are still 936,000 farmer households or 3.86 million rural residents have no access to electric power supply. The institutional defects and delayed institutional reform in rural electrification have seriously impaired effects of the electric power policies. Thus, it is still a long way to go for China to set up a sound institutional framework, financing policies and vigorous county-level electric power supply enterprises.

Contents

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1. Introduction

In China, rural electric power system involves three aspects: first, the electric power generation in the rural area, mainly by small hydropower stations; second, the rural power grid construction and electric power supply, mainly the low voltage distribution grid; and third, the rural power management system. In some African countries the rural electrification was regarded as energization via the power grid access. With the development of renewable energy, its definition has been continuously developed. Obviously, China's rural electrification is different from those African countries [1]. Constrained by the urban and rural separatism, the rural power grid has long been laggard and in a weak position, and consequently the rural power supply and services have been relatively backward. In China the rural power supply and services normally cover the areas of county- and township-level and below (except county seats), undertaken by 1924 county-level power supply branches of the State Grid Corporation of China, covering 662.5 million rural population. The 338 county-level power supply branches of China Southern Power Grid serve 134.4 million of the rural population [2].

The development history shows that the initial investment in the rural power facilities mainly came from farmers. In 1998, China renovated the rural grid and promoted the rural power management system reform. Since then, the main source of investment has been transferred to the central government and the power grid companies. The year of 1998 also became an important milestone in China's rural power development. From then on, China carried out several major construction projects and realized eye-catching achievements across the world [3].

The paper is to analyze impact of policies and mechanism to China's rural electrification. It consists of six parts: the second part, closely following the Foreword, introduces major projects implemented in the rural electrification; the third part analyzes evolution and effect of rural electrification policies and gives evaluation accordingly; the fourth part focuses on the challenges that China is facing in rural electrification; the fifth part elaborates institutional defects and obstacles in China's rural electrification and a conclusion is presented in the sixth part.

2. Electrification projects implemented in China's rural area

China's rural electrification has transformed from backwardness to advancement and from urban–rural separatism to urban–rural integration [4]. In the process of transformation, the electrification projects are of iconic significance and play a critical supporting role.

2.1. Poverty alleviation and common prosperity program through improving electricity accessibility

In 1994 the central government formulated the Seven-Year Priority Poverty Alleviation Program (a program designed to lift 80 million people out of absolute poverty in a seven-year period from 1994 to 2000). According to the deployment of the State Council, the electric power system designed the poverty alleviation and common prosperity program through improving electricity accessibility, aiming at covering 28 counties without electricity access with the power grid, enabling 95 percent rural households to have access to power supply within seven years and improving the power supply so as to better meet economic development requirements in rural areas. One year after implementing the program, nearly 60 million farmers from all administrative villages of 24 provinces (municipalities and autonomous regions) gained access to electricity. Shandong was China's first province which achieved power access to each household. At the end of 1997, 95.9 percent of the rural area has been covered by the power supply system and the proportion of the rural power consumption increased to 33 percent of the national total [5].

Meanwhile, the rural power management system has been strengthened and improved and a five-level management system from the central government to the township level has been established. Before June 1998, China had about 2400 county-level power supply companies, including 760 directly managed by central power authorities for direct electricity supply, 1040 subordinated to provincial power corporations for electricity wholesale, and the remaining 600 county-level electricity supply companies mainly working on small hydropower stations built and managed by local governments (mainly townships and towns) [6].

2.2. Rural grid construction and renovation project

To improve the weak and backward rural grid construction, in October 1998, the State Council brought forward "to reform the rural power management system, renovate the rural grid and realize the same pricing of electricity between the urban and rural areas for the same grid". The funds for the rural grid renovation came from two sources: 20 percent from the national debts issued by the central government, which was designated as the special capital; 80 percent from the bank loans, most of which were mainly borrowed by the central grid enterprises. In addition, it was determined to increase two cents per kW h electricity for the repayment of capital and interests.

From August 1998 to the end of 2002, China renovated the rural grids of more than 2300 counties in two phases with more

than 200 billion yuan of investment in total. The technical level and scale of the rural grid saw a rapid improvement [4].

2.3. County power grid construction and renovation project

To improve the country power grid operation conditions, increase supply capacity and reliability of the country power grid to better meet demand on increasing power consumption of the counties, the Chinese government designed the fixed assets investment plan for the county power grid construction and renovation in 2003. The planned investment was 3.34 billion yuan, mainly consisting of the funds of special public debts from the central government and funds and loans of the power grid enterprises.

At the end of 2004, the Chinese government launched the western China rural power grid improvement program to increase the rural grid renovation coverage and address the power supply of population without electricity access and in 2006 the project was expanded to the central China [7].

2.4. Electrification of rural small hydropower stations

Rural small hydropower stations refer to those with the installed capacity of 50 MW and below. At the beginning of the reform and opening up, China's power construction mainly concentrated in the urban areas and the outskirt, and the power facilities in most rural areas were rather outdated; the Chinese government tapped enthusiasm of the central government and the local governments and encouraged investment from multiple investors in the power facilities and local hydropower resource development for the nearby power supply. This move realized the rural electrification with the small hydropower stations. With the policy support and fiscal subsidy, the Chinese government encouraged the local governments and farmers to develop the small hydropower stations while implementing the rural electrification program with small hydropower stations [8]. Since the Chinese government launched the pilot county construction of rural electrification with small hydropower stations in 1983, three batches of rural electrification programs had helped 653 counties realize primary electrification from the 7th Five-Year Plan period (1986–1990) to the 9th Five-Year Plan period. In the 10th (2001–2005) and 11th Five-Year Plan period (2006–2010), 815 counties have realized rural electrification with small hydropower stations [9].

In 2003, in order to address the energy demand of rural residents from the areas for returning farmland to forest, protect the ecological environment and promote sustainable development of the society, the Chinese government implemented the pilot construction of special project on offering fuel alternatives by developing small hydropower stations in areas with affluent small hydropower resource, high population density and where farmers have exigent demand on fuel alternatives, especially in western China. This project, with a total investment of 280 million yuan, benefits 26 counties from Sichuan, Yunnan, Guizhou, Guangxi and Shanxi, involving more than 200,000 rural residents, and 1.56 million mu (104,000 ha) of natural forest reserves, natural reserves and areas suffering from serious soil erosion. In 2006, the Chinese government extended the special project on offering fuel alternative by developing small hydropower stations to 80 counties from 21 provinces (autonomous regions and municipalities). The project involved 169,000 rural households, or 636,000 people and a total investment of 1.03 billion yuan [9].

2.5. Every family energized project

To address the electricity access of about 1.4 million rural households, or 5.5 million rural residents in the area under coverage of the corporation, the State Grid Corporation designed the development strategy of "new countryside, new power supply and new services" in early 2006 and regarded implementation of the ""every family energized" project" an important task of the socialist new countryside construction. From 2006 to 2009, the corporation had offered electricity supply for 1.262 households, or 4.755 million people who had no access to electricity before, and completed investment of 14.83 billion yuan [10].

2.6. Renewable energy projects for the poverty-stricken areas in western China

In addition to the nationwide rural electrification program, the Chinese government implemented the renewable energy development projects in light of the actual requirements of the poverty-stricken areas in western China.

(1) **"Brightness Project".** In response to the Brightness Project introduced at the World Solar Peak Conference in Zimbabwe, the Chinese government established and started to implement the Chinese Brightness Project in September 1996, aiming at solving the power supply in remote areas by leveraging their abundant wind and solar energy systems. The then State Development Planning Commission designed the Phase I action plan for the Project in combination with the western China development strategy and planned to input about 10 billion yuan in total within five years, which consisted of appropriation from the central government and the local government, to address the power supply of about 1.8 million households of farmers and herdsmen, or 2000 administrative villages [11].

(2) **"Township electricity access project".** To address the backwardness of rural electricity supply of western China, the Chinese government launched the "township electricity access project" in 2002 to set up more than 720 independent off-grid PV power stations in Tibet, Qinghai, Xinjiang, Sichuan, Inner Mongolia, Gansu and Shaanxi. The central government formulated different funds supporting plans for different provinces (autonomous regions): 100 percent appropriation for Tibet Autonomous Region, 80 percent for Qinghai, and 50 percent for Xinjiang, Sichuan, Inner Mongolia, Gansu and Shanxi, and the remaining part to be borne by the local governments, respectively. The appropriation from the central government and the local governments totaled about 1.8 billion yuan. The project solved the living electricity demand from 200,000 households, benefiting about 1 million people [12].

3. Development, effect and assessment of rural electrification policies

3.1. Development of rural electrification policies

3.1.1. Before 1998

In China, the rural power system was a product of the dual economy with obvious marks of the planned economy. Different from the urban power facilities which were funded by the government, the rural power facilities (in some areas including construction of the power sources such as the small thermal power stations and small hydropower stations) were funded by

farmers and the rural collective economic organizations. From 1949 to 1997, the rural power grid was mainly funded, managed and used by the rural local governments (mainly the township and village level) and local farmers. The main funding source of the power grid construction was farmers and rural economic organizations (Table 1) and the subsidies from the central government were tiny. In that period, the rural power grid lacked financing channels and reliable financing sources like banks, nor did it have a united planning.

Due to the shortage of funds, the power supply system was normally poor in reliability and high in grid loss. And the system failure and blackout impaired the normal service life of power facilities. After the reform and opening up, the rural economy developed rapidly and the weak rural power grid could not meet requirements of rural economic development. In 1997, most farmers were quite discontented with rural power services and their high prices, which attracted attention of the central government.

3.1.2. After 1998

The rural electrification policy (Table 2) is closely linked with the rural economic situation and rural policies of China.

In 1998, to cope with the Asian financial crisis and expand domestic demand, the central government proposed to enforce the rural infrastructure building, including the rural grid renovation. In January 1998, the State Council decided to "renovate the rural power grid, reform the rural power management system and implement the same electricity pricing for rural and urban power grids"[4]. The policy mainly includes the following three aspects:

First, the rural power grid loan repayment policy. To address the interest and principal repayment of the rural grid loans, the State Council decided to increase the price (2 cents per kW h) of electricity to repay the loans for the Phase I & II rural grid construction and renovation which would be implemented soon.

Second, policy of transferring the onlend funds of the fiscal investment to capital funds. The capital funds of Phase I &II rural grid construction and renovation project were jointly borne by the central government and the local government in the form of discount loan. To support the development of the rural grid of western China, the central government decided to transfer part of the onlend funds to appropriation. This move significantly improved the financial status of the grid enterprises.

Third, the policy's concerning the rural grid low-voltage maintenance and management fees. In history the low-voltage electricity assets of the rural areas consisted of the state-owned assets, collective assets and users' assets. The incurred maintenance and management costs were jointly borne by the power supply enterprises, the township (town) power management stations and the owners of the assets according to the ownership structure. To ensure the normal maintenance to the low-voltage grid assets and pay to

Table 1
Rural power grid investment and its structure in 1996.

Province	Total amount (million yuan)	Subsidy from provincial government (%)	Prefecture government (%)	County government (%)	Township government (%)	Farmer (%)
Hebei	105.90	2	1	6	4	88
Liaoning	1190.20	0	0	1	6	93
Jiangsu	77.11	2	2	6	4	85
Henan	55.24	2	2	1	5	90
Shaanxi	48.38	2	1	5	1	92

Table 2
Main policies concerning rural electrification after the founding of new China.

No.	Main policies
1	In 1963, the Ministry of Water Resources and Electric Power established the Rural Electrification Bureau and set up the development guideline "give priority to the commercial grain and cotton bases, focus on meeting the irrigation and drainage power consumption demand, make the grid power supply as the main force and put equal emphasis on development of the power grid and the small rural stations"
2	In 1969, the State Council formulated policies to encourage the counties, communes and production teams to develop the electric power system and implemented the policy "those who build and manage the power station own it"; and the central government offered 20 percent subsidy
3	The State Council set up the tasks of building 100, 200 and 300 electrified counties with small rural hydropower stations during the 7th Five-Year Plan period (1986–1990), the 8th Five-Year Plan period (1991–1995) and the 9th Five-Year Plan period (1996–2000), respectively
4	The State Development Planning Commission printed and distributed the notice on application for adjusting the Power Supply Subsidy Standards and Enforcing Subsidy Management (Ji Tou Zi [1993] No. 116)
5	In February 1994, the Ministry of Electric Power first proposed the "Poverty alleviation and common prosperity program through improving electricity accessibility", which was included in the Seven-Year Priority Poverty Alleviation Program upon approval of the State Council
6	In April 1998, the State Development Planning Commission released the Circular on Enforcing the Rural Power Price Management and Putting Down Arbitrary Price Increase and Charges
7	In October 1998, the State Council released the Circular on distributing application of the State Development Planning Commission for restructuring Rural Power Grid, Reforming Rural Power Management System and Implementing the Same Electricity Pricing for Urban and Rural Power Grids by the General Office of the State Council ([1998] No.134 document of the General Office)
8	In January 1999, the State Council promulgated the Circular of the State Council on approving the State Economic and Trade Commission's Opinions on accelerating the Rural Power System Reform and Enforcing the Rural Power Management ([1999] No. 2 Document]), providing comprehensive reform guidelines, policies and plans for the rural power system reform
9	On August 19, 2004, the National Development and Reform Commission distributed the Circular on improving the Rural Grid Renovation Investment Scale and relevant requirements of western China (Fa Gai Energy [2004] No. 1740)
10	Renewable Energy Law was enacted in 2005 and officially came into effect in January 2006
11	The Circular on Improving the Rural Gird and Electric Power Building of the areas without access to Power Supply during the 11th Five-Year Plan Period by the National Development and Reform Commission (Fa Gai Energy [2007]No.421)
12	In the No. 1 Documents from 2006 to 2009, the central government raised continuous requests:: enforcing the rural power grid development, enlarging coverage of the rural power grid, increasing investment in the small hydropower stations; in 2010, the No. 1 Document of the central government requested to implement the new round rural power grid renovation and upgrade program

the maintenance personnel, the central government promulgated the policies: the maintenance and management fees of the rural low-voltage grid, which mainly consists of the rural energy losses, reasonable electrician remuneration and rural grid operation fees, shall be included in the local electricity sales price.

For a long time, the rural electricity infrastructure and farmland water conservation infrastructure and other infrastructure were mainly constructed by farmers and rural collective economic organizations with subsidies from the central government and no radical changes were made until early 21st century. In 2003, the Ministry of Finance of China proposed for the first time to make the public finance to shine in the rural areas. This is a significant change of the guiding concept that the public finance supports the rural works and also the commencement for the public finance to cover the rural programs [13]. Since 2004, No. 1 Document of the Chinese government each year has a distinctive theme: narrow gaps between the rural and the urban areas, enhance the urban and rural economic and social integration; expand the coverage of the public finance to the rural areas and promote input in the rural public services from the government, give priority to changing the urban–rural dual structure from the roots and gradually address issues concerning the countryside, farmer and agriculture. Since 2006, No. 1 Document of the Central Government has included the rural grid and other infrastructure construction into the agenda. Since then, the rural electrification policy has been raised to the central government level and the specific rural electrification policies and measures have become an integral part of the rural economic and social development policy.

After 1998, the main sources of the rural gird construction funds have been radically changed from relying on the local governments and farmers to mainly depending on support of the public debt, investment from power supply enterprises and loans. The change can be seen in Anhui, an agriculture-based province (see Table 3). After 1998, China has basically solved the difficulty of funds shortage that had troubled the rural grid development for a long time. It indicated an important change of the rural electrification development.

3.2. Effect of the rural electrification policies

The Chinese government has designed effective policies to boost the rural electrification and made achievements that have captured world attention.

3.2.1. Obviously improved rural grid guarantee capability and power supply quality

3.2.1.1. Mature rural grid system and reliable guarantee capability formed. Since 1998, the Chinese government has totally input more than 500 billion yuan in the rural grid construction and renovation, and the rural grid improvement program in central and western China, generally setting up a nationwide modern rural grid system. From 2006 to 2009, China has completed electrification of 302 new countryside counties, 3706 towns (township), and 64,933 villages in total, and effectively improved the rural electricity infrastructure and provided safe and reliable electricity guarantee for the rural economic and social development [10].

3.2.1.2. Significantly improved power supply reliability and quality. With the rural grid renovation program, the county power supply enterprises have improved safe production and management level with constantly increasing reliability. The power distribution losses were reduced to a reasonable level and more than 95 percent of the user-end voltage in the rural area met the designated standards, increased by 12 percent compared with that before renovation; the power supply reliability rate reaches over 99 percent, up 8 percent compared with that before renovation (see Table 4).

3.2.2. Improved rural electrification and reduced rural electricity price

3.2.2.1. Significantly improved coverage of the rural power supply services. In 1978, the electricity access rate of county, township (town) and village was 94.5 percent, 86.83 percent and 61.05 percent, respectively. With the rural grid renovation program, the grid coverage has been significantly increased (see Table 5).

3.2.2.2. Substantial growth of rural electricity consumption. In 2007, the rural social electricity consumption under the coverage of the State Grid Corporation of China was 133.1 billion kW h, 29 times of that in 1978. And the proportion in the total social consumption was increased from 25.75 percent in 1978 to 40.87 percent in 2007 (see Fig. 1).

3.2.2.3. Rural electricity price cut greatly benefits farmers. From the nationwide aspect, the household electricity price of the rural areas was cut from 0.7560 yuan/kW h in 1998 to 0.5390 yuan/kW h in 2007, alleviating farmers' burden on lighting costs by 23.3 billion yuan in 2007 alone [10].

Table 4
Changes of power supply reliability, voltage qualification rate and line losses in the rural area (%).

Index	1978	2002	2005	2009
Power supply reliability	94.55	99.30	99.38	99.61
Voltage qualification rate	85.17	94.24	95.80	97.25
Comprehensive line loss rate	17.02	12.11	12.00	10.01

Table 5
Changes of electricity access rate after the rural grid renovation (%).

Index	1998	2002	2005	2007
Township electricity access rate	98.20	98.54	99.90	100.00
Village electricity access rate	98.10	98.71	99.80	99.70
Household electricity access rate	93.87	98.48	99.40	99.69

Table 3
Investment of Anhui province and its sources in rural grid construction and renovation between 1998 and 2009.

Period	Total amount (100 million yuan)	County power supply enterprises (%)	Public debts (%)	Bank loans (%)
1998–2003	95.65	13.22	17.35	69.43
2004–2006	25.01	40.84	11.20	47.96
2008–2009	54.95	59.05	8.19	32.76
Total	175.61	64.40	13.61	21.99

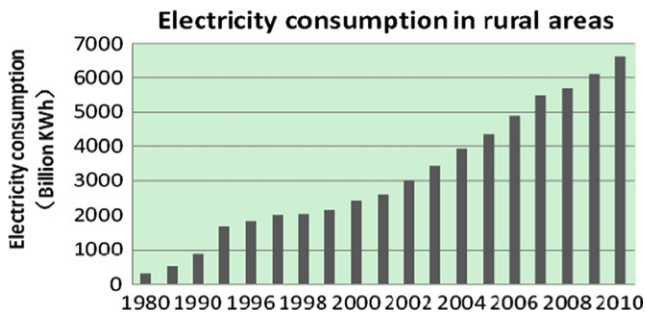


Fig. 1. Electricity consumption in rural areas.

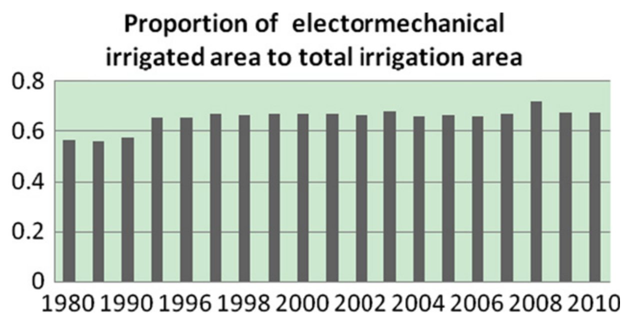


Fig. 2. Proportion of electromechanical irrigation area to total irrigation area.

3.2.2.4. Remarkable growth of electromechanical irrigated area. China saw accelerated development of agricultural mechanization, electrification and water conservation, quicker paces of farmland construction and constant growth of electromechanical irrigated area (see Fig. 2), which increased irrigated area and grain yield.

3.3. Small hydropower systems brighten rural area of China

3.3.1. Small hydropower systems cover rural areas

China has made remarkable achievements in the small hydropower system development in the rural area with the system covering 1/2 of the territory, 1/3 counties and cities and enabling more than 300 million rural population to have access to electricity. Small hydropower systems has brightened the rural area of China. With more than 60 years of development, China has built 45,000 small hydropower stations, with a total installed capacity of 59,000 MW and annual power generation of more than 200 billion kW h, or 30 percent of the total installed capacity and annual power generation [14].

3.3.2. Generally improved power supply services

The electricity access rate of more than 1000 counties that realized electrification with small hydropower stations was increased from less than 40 percent in 1980 to 99.8 percent in 2010 and the average annual household consumption was increased from less than 200 kW h to 800 kW h in the same period. The power supply quality and reliability have been improved remarkably, which significantly enhanced the county economic development [15].

3.3.3. Improved living and production conditions for poverty-stricken farmers

The small hydropower resources of China distribute in more than 1700 counties, basically coinciding with the distribution of poverty-stricken mountainous areas and ethnic areas. The local development and power supply of small hydropower stations solved the problem of power supply for production and living of the dispersed population and those in remote and poverty-stricken mountainous areas; at the same time, it has improved the rural infrastructure, harnessed the small and medium-sized rivers, created 211.8 billion cubic meters of reservoir capacity, increased 25.30 million hectares of effective irrigation area, solved the difficulty of drinking water supply to 64.25 million people and 47.42 million big livestock, improved the capability of flood control and drought resistance, promoted development of the rural public welfare and increased incomes of farmers [16].

3.4. Evaluation to rural electrification policies

3.4.1. Rural electrification policies lack of long-term comprehensive considerations

Since 1998, the central government has implemented the rural grid construction and renovation program and set up a rural electricity development system relying on the investment from the central government in infrastructure and investment from power grid corporations. However, the system is not sound as the investment was made in the manner of “blood-transfusion” and “centralized mobilization”, with obvious periodic and expedient features and lack of long term and comprehensive consideration.

China is at a stage of rapid industrialization and urbanization. With rural economic development and transfer of the secondary and tertiary industries to the rural areas, and improvement of the living standards of the broad rural residents, the rural power consumption grows rapidly with a great growth potential. From 1998 to 2007, the rural power consumption grew 16.41 percent annually in the areas covered by State Grid Corporation, 5 percentage points higher than the overall social power consumption growth rate. Some areas even saw 20–30 percent of growth annually [10]. Most of the power supply equipment renovated in Phase I and II rural grid renovation program have confronted with heavy-load, full load or overloaded operations. Compatibilization and capacity expansion were in urgent need. The rural grid met its “bottleneck” again. However, the central government had not designed any new rural grid investment policies. Moreover, there is no investment and financing system in place for the rural grid development. As a result, there is no stable and effective source of funds for the rural grid construction and development.

International experiences show that the support policies from government to rural power development include offering fiscal, technical and law assistance, making rural grid development planning, and studying out rural grid operation and management codes, and training. The policy support can guarantee stable sources of funds and ensure smooth implementation of the rural power construction; the government shall develop specific policies and legislation to form a relatively independent support system of policy and law for rural power development.

3.4.2. Formulation and implementation of rural electrification policies are not in concert with China's overall urban–rural development requirements

After 2006, no substantial changes were made to the rural electrification policies and institutional reform. Though in the previous five years the central government has made clear instructions for the rural power development in the No.1 Documents, there was no united authoritative command and organization for implementation of the rural power development policies due to the lagged institutional reform and the effect of policies were greatly reduced. What is worthy of notice is that State Grid Corporation and China Southern Power Grid are responsible for the rural power development of most rural areas and formulation and implementation of the rural power policies[17]. Considering the dual roles of profit-making operation and social public utilities

of these corporations, it is neither fair nor realistic to request them to implement the coordinated urban–rural development guideline formulated by the central government from the level of state policy maker.

3.4.3. Rural power universal service policy system is not established yet

In modern society, electricity is increasingly important for the production and living of people. To protect the basic rights and interests of all citizens and narrow gaps between the poor and the rich, most countries normally enact laws and policies to meet electricity needs of all citizens for the basic living at a generally acceptable price, or implement the electricity universal service. The electricity universal service is actually a special service provided by the state for its citizens in the areas with high electricity costs and low-income citizens.

The universal service function was realized by internal cross subsidization of electricity corporations when China implemented the vertical integrated operation in the electricity industry. In 2002, after China's electricity market reform, or "separation of power plants from power grids", the power plants and power grids became independent market competitors. The operation objectives and strategy of power grid corporations became contradictive with the universal service principle. And problems in the electricity universal service gradually exposed and attracted high attention from the government. However, to date the universal service system has been lack of a well-defined legal framework, specifically, there is no law requiring monopoly enterprises must bear the social burdens, or stipulating the legal status of the cross subsidization. The "project to make electricity available to every household" was realized as a social burden of electricity corporations [18,19].

China still has more than 700 million people living in the rural areas. Limited by the economic and technical level, most rural areas are still using the biomass energy in the traditional way. The mission to realize the electricity access for those without electricity supply is still arduous and needs a heavy investment. This will depend on the establishment of a policy system for the electricity universal service [20].

4. Challenges during China's rural electrification

4.1. Nearly one million households without electricity access in western China

Though China's electricity industry enjoys a rapid development and can basically meet needs of economic and social development, China is a vast country with unbalanced economic and social development, and the remote rural areas, pasturing areas and islands still face very outdated electricity facilities due to limitation of historical and natural conditions. According to the State Electricity Regulatory Commission, by July 2012, there are 256 townships (towns), 3817 villages, 936,000 households, or 3.87 million of population, having no access to electricity. Of that, ethnic population accounts for 84 percent of the total without access to electricity, mainly in the poverty-stricken areas of Xinjiang, Tibet, Sichuan, and Qinghai [21]. The lack of basic electricity facilities seriously hindered the economic and social development of these areas and improvement of the living standards of people there. The solution to electricity supply of the areas without access to electricity has became an important task to promote coordinated regional economic development, improve the production and living conditions, shake off poverty and realize the objectives of a well-off society.

4.2. The regional gap of rural electrification level

China's rural electrification level is still very low and the power consumption in rural areas varies remarkably from area to area. The rural power consumption in 2005 indicates that the annual per capita rural power consumption was 970.9 kW h in eastern China, which was 5.6 times of that in central China, and 6 times of that in western China. The gap of per capita rural household power consumption between the east and west was also quite large. In 2006, the per capita rural household power consumption was 103 kW h, while the figure of Beijing rural area was 434 kW h, more than 14 times of that of Tibet Autonomous Region [3]. The regional difference in rural power supply is also large: the rural power consumption in the coastal, developed areas and outskirts is almost the same as the urban areas; but the difference between the urban and the rural in central and western China was quite large.

4.3. Difficulties in electric project construction and financing

The rural power supply is a sort of welfare, fundamental and naturally monopolized service in China. As the rural population of China are scattered, the rural power grid has to provide a great number of service outlets with a long distribution line, low power consumption, high losses, high investment and poor economic performance. The power supply cost is much higher than that in urban areas.

Since 2000, the Chinese government has offered power supply for 6.07 million households, or 24.14 million of people without access to electricity through various means. The existent poverty-stricken areas without access to electricity in western China have complex geographic conditions. The high difficulties in electricity access projects, high costs of construction (see Table 6), large funds gaps and difficulties in financing made the projects difficult to promote [22].

4.4. Differences in operation and power supply service capability of county power supply enterprises among the east, the central and the western China

The power supply cost in the rural areas is higher than that in the urban areas. According to the principle of cost dictating price, the power sales price in the rural areas shall be higher than that in the urban areas. However, it is impossible to significantly increase the rural electricity price due to the rural economic development level and the electricity pricing policy. Considering the differences in the natural conditions and economic development level of areas served by different power supply enterprises, the power supply enterprises in the poverty-stricken areas have high responsibilities and accordingly face more difficulties in providing universal electricity access and universal service and in operation [23]. The unbalance in economic and social development between the eastern and the central and western China leads to gaps of the management performance of the county power supply enterprises among these regions. Eastern China enjoys a rapid social and economic development and generally good rural grid infrastructure. The county power supply enterprises there have relatively large assets and good assets quality, and the rural power market has a larger potential and users

Table 6
Costs for electricity access of rural households of western China. Between 2006 and 2009.

Year	2006	2007	2008	2009
10,000 yuan/household	1.01	1.27	1.25	1.42

have better affordability to the electricity price. The investors of county power supply enterprises there also have a relative stronger financial strength. As a result, the county power supply enterprises in eastern China have a better survival and development capability and good external environment and accordingly a stronger attraction to external investors. In central China, the social and economic development gaps are large among different areas and some countries have better economic conditions, some are underdeveloped or backward. The gaps of rural power market potential and users' affordability to electricity price are large to. Except for counties with direct power supply and management from the provincial power supply enterprises, the other county power supply enterprises have limited funds. Therefore, the power supply enterprises in these counties need governmental support to survive and develop; the economy of western China is backward and most power supply enterprises there have poor profit-making capability constrained by the natural conditions and local economy for a long time.

In conclusion, the unbalance of rural economic and social development among the eastern, central and western China leads to the difference in service capability of the local county power supply enterprises.

5. Institutional barriers in China's rural electrification

5.1. Poorly defined management functions

Problems existing in the rural power management include: the policy maker for the rural power development is not clear and the policy responsibility is not compatible to right; the macro-control to rural power is seriously lagged and the government function is not in place in the rural power management. Though the central government established the National Energy Administration (NEA), no division is set up for the rural power management. After cancellation of the State Economic and Trade Commission, there is no clear definition for which department to undertake the function of rural power administration. In the local government, the functional department establishment corresponds to the central government, and the administration function of the local government has been weakened in the rural power supply enterprises. The rural power planning and power facility protection are lack of authoritative coordination and organization and the administration function is vacant, for example, the universal service responsibility, supporting policies (including direct investment, discount loans and low-interest loans and policy-related subsidies for the rural power development) and preferential policies on tax, price and others.

5.2. Poorly defined function and power division between the central government and local government

For a long time, the electricity industry exercised vertical management and integrated operation of power grid, power transmission, distribution and sale. As a result, the function of local governments on electricity management was relatively decentralized. At present, the power development planning, investment, pricing and operation area division and asset management are functions of the State Development and Reform Commission, Ministry of Industry and Information Technology, Bureau of Price, Ministry of Finance, State-owned Assets Management Committee and Ministry of Water Resources and others, respectively. To a large extent, there is lack of coordination and cooperation among them. Therefore, the lack of authoritative coordination and organization on the rural power planning and facility protection leads to that there is no clear and long-term planning for the rural power universal services and rural power development policies [24,25].

5.3. Lack of effective compensation system for electrification poverty-stricken areas

The rural power supply features a long radius, low load density and high unit cost, especially in the poverty-stricken areas in western China where objectively require for necessary policy support from the central government and local governments. Throughout a long term, China has taken various policies and measures for the rural electrification and rural grid renovation [25]. However, these policies and measures lack of completeness and stableness, for example, the absence of financial, credit and tax and other preferential policies for the rural power enterprises, as well as scientific policy system supporting the rural power supply enterprises. These facts lead to serious losses and hard to survive for most rural power supply enterprises in western provinces and poverty-stricken areas.

After 1998, China has made remarkable achievements in the rural grid renovation and rural power development and basically built the power supply of most households without access to electricity. However, the policy on rural grid renovation and rural power investment was designed from the aspect of making up the historical debts and solving the actual important problems, and was passive and short-term countermeasures and lack of legal support and long-term considerations. The electricity universal services are realized in China mainly through cross subsidization among different areas, different businesses and different voltage levels with the provincial power enterprises as the main entity in charge and service providers. The main problems in the rural power universal service include: poorly defined responsible entity, lack of clear objectives, scope and legal basis for the universal service, lack of well-defined sources of funds and cost compensation system.

5.4. Deficiencies in the power supply enterprise incentive and restraint system

The power supply services of rural areas are undertaken by 2730 county-level power supply enterprises, of which 1924 or 70.5 percent managed by State Grid Corporation, 338 or 12.4 percent by Southern Power Grid Corporation, and 468 or 17.1 percent by water conservancy authorities. These enterprises can be divided into three types according to the management systems (see Table 7): power supply enterprises under custody, joint-stock power supply enterprises, county power supply enterprises directly under State Grid Corporation and Southern Power Grid Corporation.

The power supply enterprises directly under the State Grid Corporation and Southern Power Grid Corporation are state-owned enterprises with well-defined ownership and standard management; the power supply enterprises under the water conservancy authority are mostly small hydropower enterprises

Table 7
Composition of county-level power supply enterprises in 2007.

Corporation	Total	Direct electricity supply and management	Joint stock enterprises	Enterprises under custody
State Grid Corporation	1924	854	414	656
Southern Power Grid Corporation	338	181	44	113
Total	2262	1035	458	769
Proportion (%)	100%	45.8%	20.2%	34.0%

which have their own service areas and offer power supply services for the local residents relying on the hydropower stations. Among these four kinds of power supply enterprises, those under custody and the joint-stock enterprises have serious problems with deficiencies in their incentive and restraint systems.

5.4.1. Power supply enterprises under custody

The power supply enterprises under custody are those entrusted by the county (or city) government to the local provincial power grid corporation for the purpose of enforcing management, separating government functions from enterprise management, controlling overstaffing of enterprises, lowering management costs and standardizing the power supply market. Therefore, it is a sort of temporary and transitional administrative management instead of real enterprise behavior. Due to the lack of equity relation between provincial power grid enterprises and power enterprises under custody, provincial power grid corporations cannot perform overall planning and investment in rural grids of county-level power supply enterprises under custody while these enterprises receive no investment from provincial power grid corporations and lack of vitality, which directly lead to sufficient investment in local rural grids and difficulties to meet the economic and social requirements of the rural areas.

5.4.2. Joint-stock power supply enterprises

The county joint-stock power supply enterprises are jointly invested by the provincial power grid enterprises and local governments. Though exercising a modern enterprise system in form, these enterprises, with a single ownership structure, actually do not follow the standards of joint-stock enterprises in operation, nor have a sound legal person management structure, or set up a scientific and standard decision-making system and internal management system. They have major deficiencies in shareholding proportion and governance structure. Some local governments did not treat the joint-stock power supply enterprises as their own from the very beginning. When the rural grid development needs additional investment, the local governments often fail to increase investment pro rata with the provincial power grid enterprises. It was difficult for provincial power grid enterprises to adjust the shareholding proportion by increasing investment unilaterally. Institutional contradiction could easily appear when working with the local government. These facts upset enthusiasm for investment of the provincial power grid enterprises and limit sources of funds of joint-stock power supply enterprises for the rural grid construction and renovation.

5.5. Lack of effective regulation in rural electricity universal service

In many countries, the rural electricity universal service is considered as an important public policy of the network industry [26]. The electricity universal service is closely related to the economic development objectives. That requires the government to set up appropriate universal service goals. What level of the universal service could be reached and how to implement in phases need scientific design. On the other hand, the government needs to set up an appropriate system according to the scientific objectives. To date, China's rural electricity universal service is lack of well-defined regulatory objectives, scope and standards and the legal and policy basis.

6. Conclusion

In China the rural electricity was a product of the dual economy with marks of the planned economy. It evolved from small to big, from backward to advanced, from urban–rural segmentation to gradual integration. The rural electrification policy has gradually become an integral part of the rural economic policy from a disassociated state. In the past three decades, the Chinese government has implemented a series of rural electrification projects and relevant policies, reformed the rural electricity system and basically set up a nationwide modern rural power grid network with improved safety and reliability. China's rural electrification policies have produced remarkable effect. The constant development of the rural electrification has satisfied the electricity demand of rural production and living; improved the material and cultural living standard and incomes of the rural residents, promoted the rural economic and social development, improved the rural infrastructure and narrowed the urban–rural gaps in energy and electricity facilities, offered important support for the new countryside building with a rural electrification rate of more than 99 percent, and remarkably improved the ecological environment.

What is not optimistic is that China is facing challenges in the rural electrification. Nearly a million of households in the remote areas in western China have no access to electricity, the rural electricity consumption is unbalanced among eastern, central and western China. and the institutional barriers seriously upset the sustainable development of rural electrification. With accelerated paces of urbanization, industrialization and urban–rural integration, the discordance between the rural electrification policy and China's coordinated urban–rural development has become evident. To successfully realize the objectives of universal access to electricity in rural areas and rural electrification, it becomes more critical to set up a sound institutional framework and policies.

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